

# **Preliminary Results of Patterns of 2019 Thermal Stress and Coral Bleaching Across the Hawaiian Archipelago**

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## Background

As ocean temperatures continue to rise at an accelerated pace, coral bleaching events across the Hawaiian Archipelago have increased in frequency and severity. The 2015 bleaching event had significant, statewide impacts. In the main Hawaiian Islands (MHI), more than 50% of the surveyed coral exhibited bleaching ranging from mild (paling evident) to severe (stark white), and the mortality that followed reduced coral cover by more than 30% (Oliver et al., unpublished data). In June 2019, NOAA's Coral Reef Watch ([coralreefwatch.noaa.gov](http://coralreefwatch.noaa.gov)) predicted that waters surrounding the MHI and Northwestern Hawaiian Islands (NWHI) were expected to reach a thermal stress Alert Level 1 (mass bleaching likely) by September and possibly Alert Level 2 (mass bleaching with likely mass mortality) by October. By September, CRW reported that ocean temperature anomalies in the NWHI and the MHI had already exceeded the 2 °C mark, with heat stress up to Alert Level 2 projected to extend throughout October. Over the last six years, the 2019 event marked the third bleaching event in Hawai'i. The frequency of these events is unprecedented in the archipelago.

NOAA's Pacific Islands Fisheries Science Center (PIFSC) Ecosystems Sciences Division (ESD) planned and conducted a multi-institutional response in partnership with the Hawaii Coral Bleaching Collaborative to build a comprehensive dataset of the spatial extent and severity of coral bleaching in the Hawaiian Archipelago. Through a combination of bleaching assessment surveys and Structure-from-Motion (SfM) photogrammetry surveys, both real-time rapid data and permanent records of reef condition were collected during the peak of the forecasted 2019 bleaching event. This report presents preliminary results of in-situ visual bleaching surveys. A forthcoming quantitative analysis will examine spatial patterns of bleaching prevalence and extent across taxa and the influence of depth and thermal stress on those patterns.

## Survey effort and design

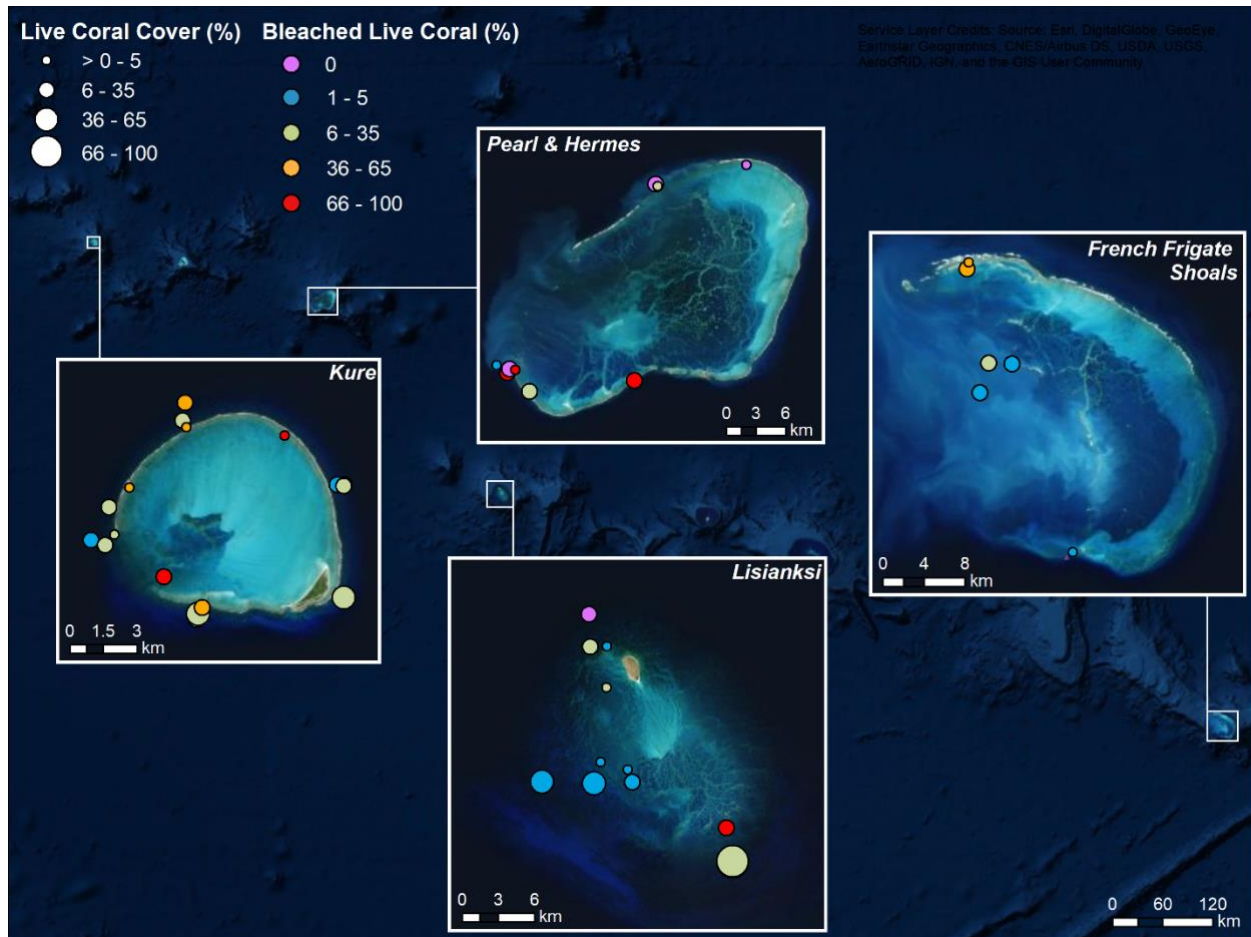
The ESD collectively conducted 46 surveys at four of the NWHI (Kure Atoll, Pearl and Hermes Atoll, Lisianski Island, French Frigate Shoals) from 27 August to 4 September 2019, and 169 surveys at four of the MHI (Hawai‘i, O‘ahu, Maui, and Lāna‘i) from 8 October to 14 November 2019 (Table 1). Surveys in the NWHI were opportunistically conducted during a scheduled NOAA National Coral Reef Monitoring Program (NCRMP) field mission and therefore did not correspond to the peak of thermal stress in September. Surveys on Hawai‘i Island were conducted in partnership with The Nature Conservancy (TNC) and the State of Hawai‘i Division of Aquatic Resources (DAR). Survey regions per island were selected based upon predicted thermal stress, locations of long-term monitoring, and accessibility. State-wide in-water assessments of coral bleaching were conducted across three depth strata aligned with the depth ranges of NCRMP’s long-term monitoring (shallow [0–6 m], mid [>6–18 m], deep [>18–30 m]) at both random and fixed sites. Except for surveys conducted on Hawai‘i Island, each site had a survey area of 154 m<sup>2</sup>. On Hawai‘i Island, the survey area varied between 100 and 154 m<sup>2</sup> amongst partners. The following data were recorded per survey: percent total coral cover, percent of the total coral cover that was bleached, and average severity of bleached coral. Severity was ranked on a scale of 1–4 (1 = minimal paling; 2 = significant loss of pigmentation; 3 = stark white; 4 = recent mortality due to bleaching). In addition, up to five of the most dominant coral taxa per site were recorded with their respective percent cover, percent of the taxa cover that was bleached, average severity, and maximum severity observed.

**Table 1. Number of rapid surveys conducted by island across depth strata from August to November 2019.**

	<i>Kure</i>	<i>Pearl &amp; Hermes</i>	<i>Lisianski</i>	<i>French Frigate Shoals</i>	<i>O‘ahu</i>	<i>Lāna‘i</i>	<i>Maui</i>	<i>Hawai‘i</i>
<b>Shallow</b>	5	4	5	4	20	6	27	18
<b>Mid</b>	8	4	4	3	29	8	22	20
<b>Deep</b>	4	2	3	0	15	2	2	0
<b>Total</b>	17	10	12	7	64	16	51	38

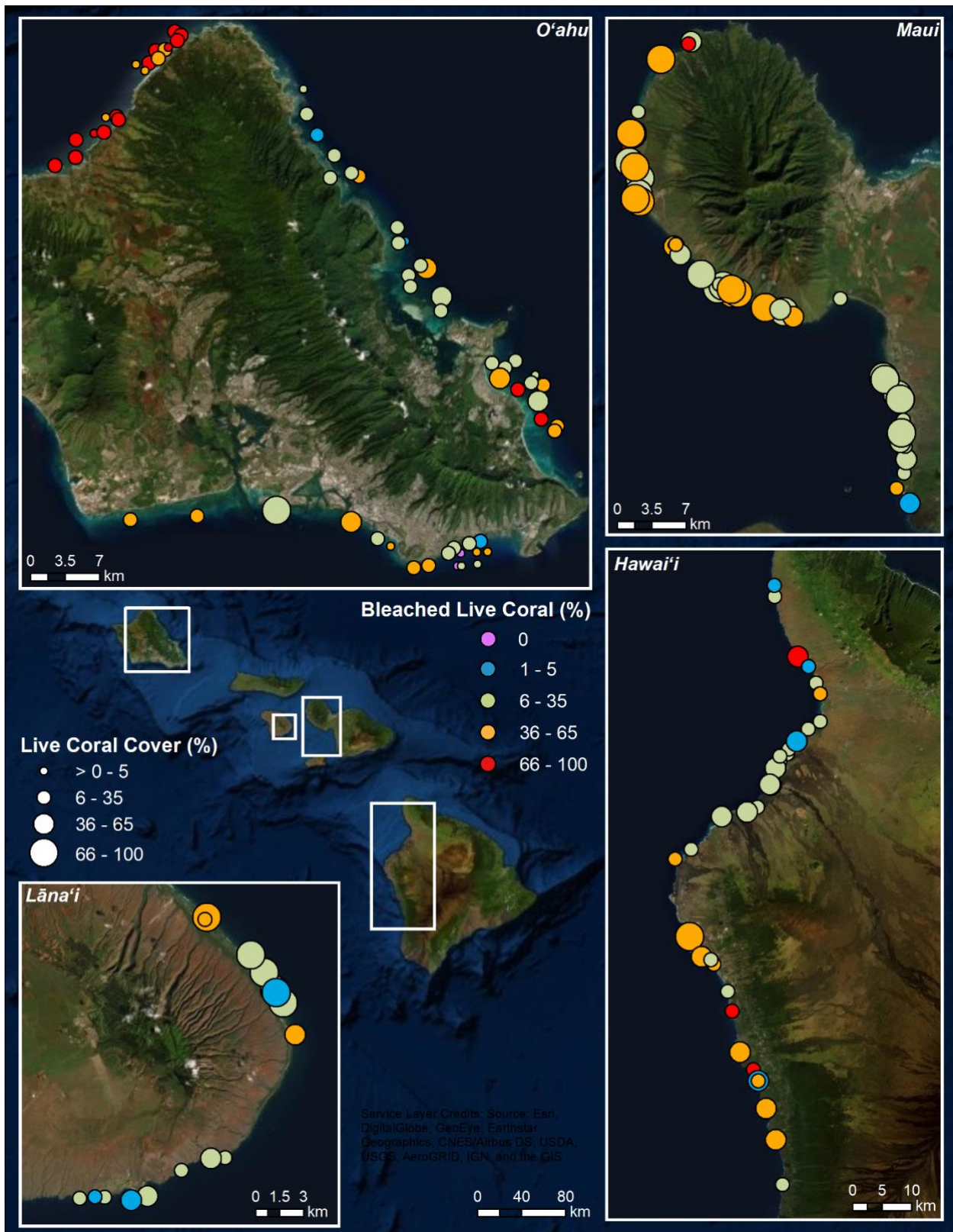
## Preliminary results

Across the Hawaiian Archipelago, the vast majority of sites visited during the 2019 bleaching event were experiencing some degree of bleaching (Figure 1; Figure 2). Surveys where no bleaching was recorded were rare, and only occurred at sites with extremely low live coral cover. Consistent with previous bleaching events in the NWHI, the northern atolls experienced the highest bleaching (mean percent of live coral that was bleached =  $33.2\% \pm 6.7$  SE at Kure and  $32.9\% \pm 12.8$  SE at Pearl and Hermes). While bleaching prevalence varied across space, the level of bleaching appeared similar within regions (e.g., northwest O‘ahu and southwest Maui).



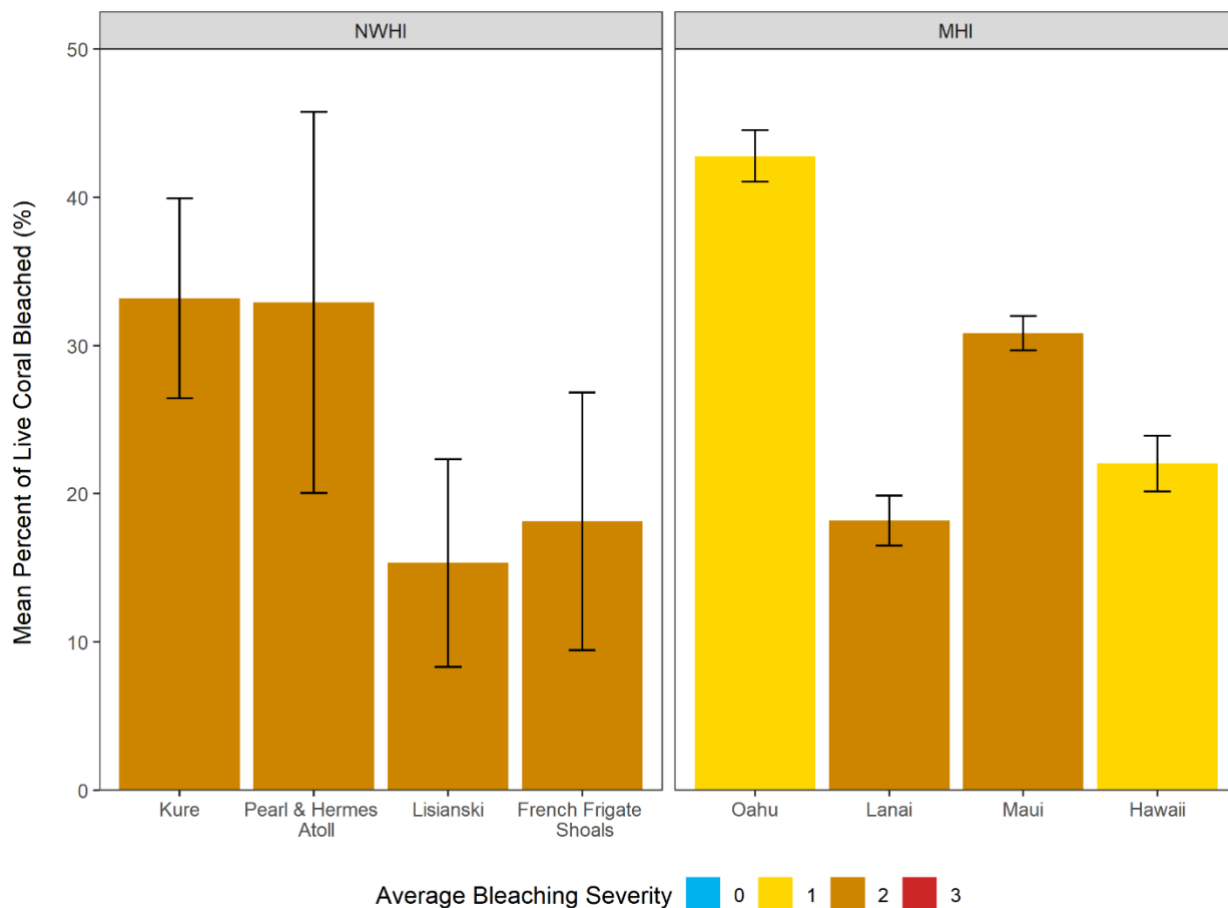
**Figure 1. Site-level percent coral cover and percent of coral that was bleached (all severity levels) across the NWHI.**





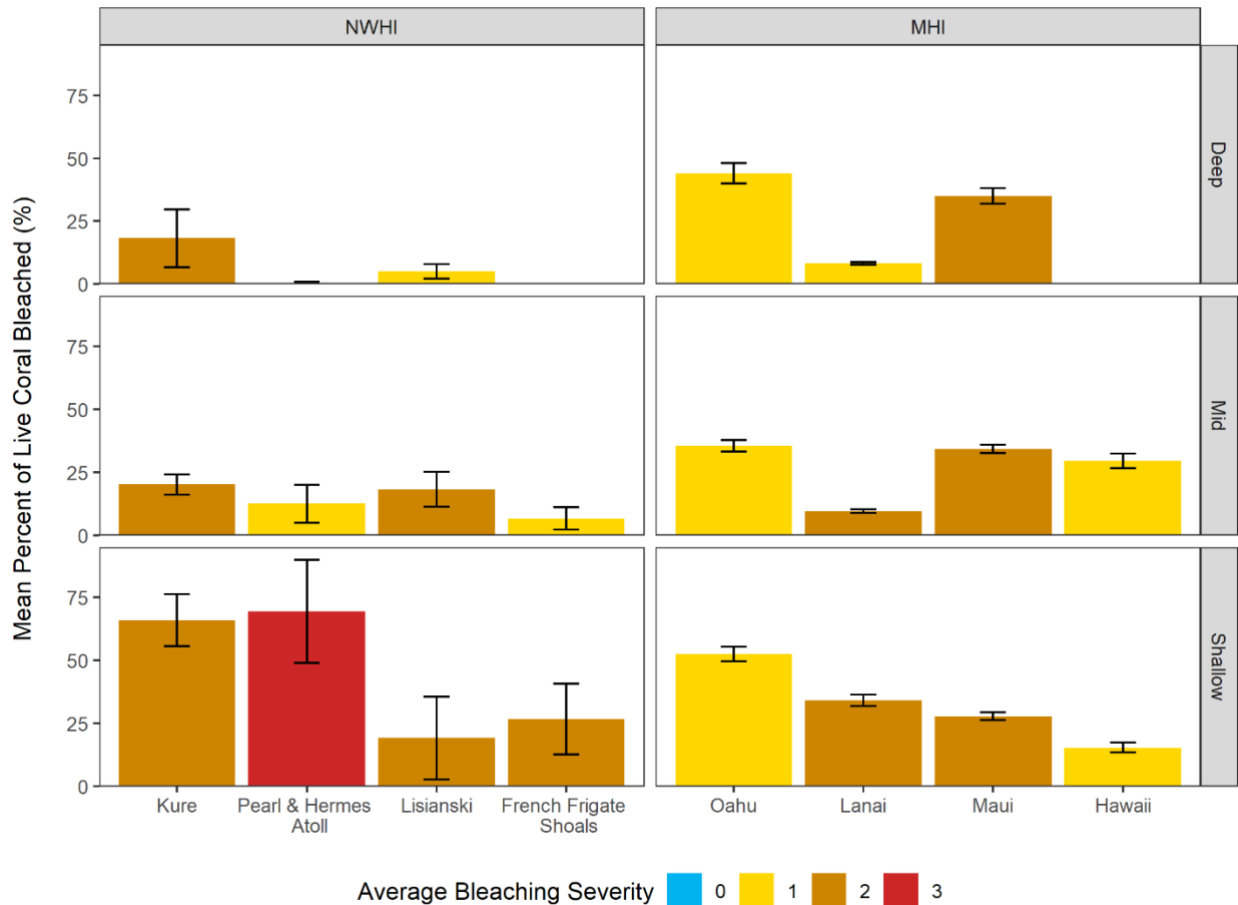
**Figure 2. Site-level percent coral cover and percent of coral that was bleached (all severity levels) across the MHI.**

The average bleaching severity across all islands was 2: significant loss of pigmentation (**Error! Reference source not found.**). Severity in the NWHI was consistent at 2, while the bleaching in the MHI ranged from 1 to 2. Greater variation in bleaching observed in the NWHI compared to the MHI is likely the result of smaller sample sizes. O‘ahu had the highest percent of live coral that was bleached (mean = 42.8%  $\pm$  1.7 SE) in the Hawaiian Archipelago. However, the average bleaching severity for O‘ahu was lower than the majority of other islands.



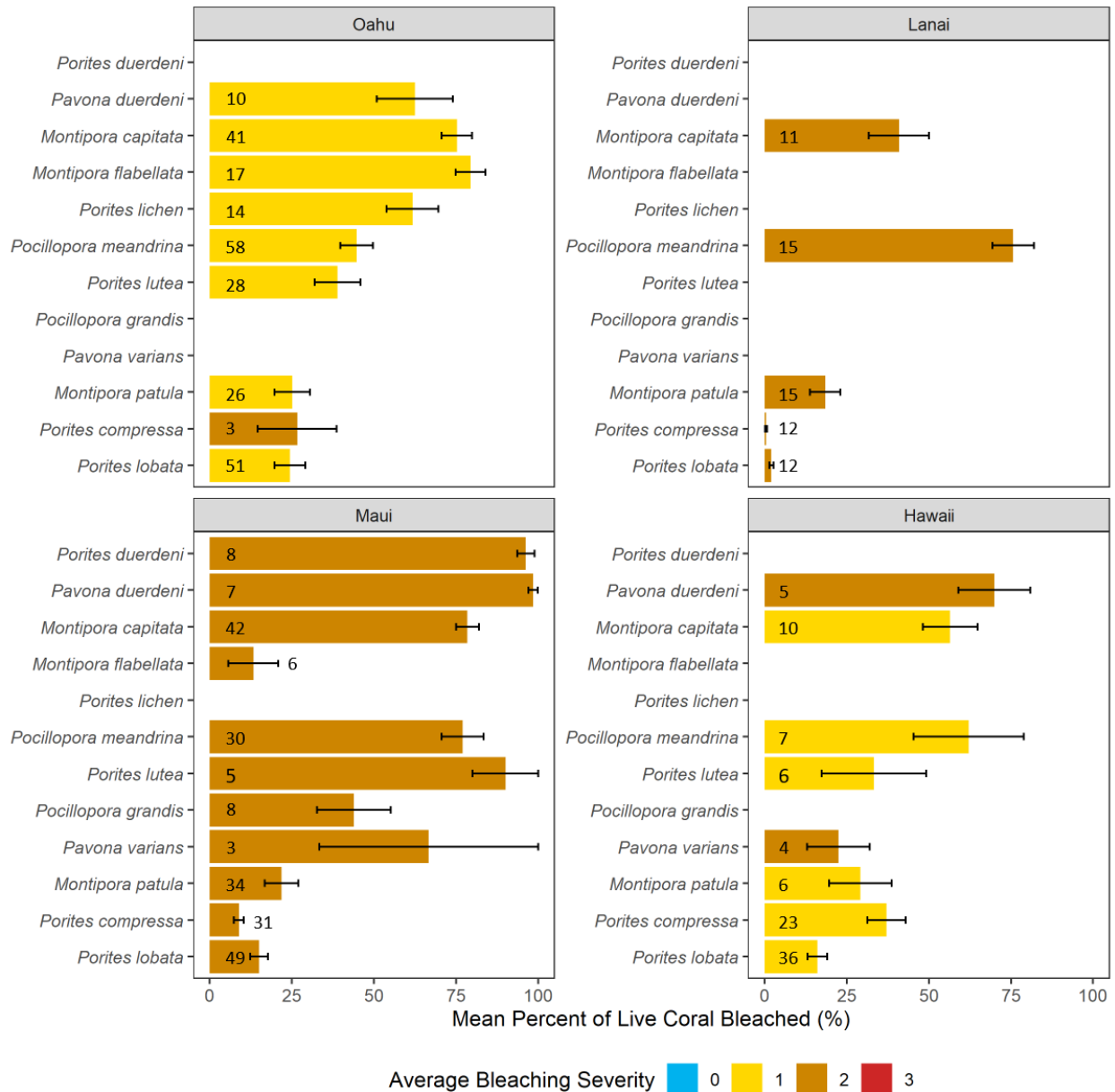
**Figure 3. Mean ( $\pm$  1 SE) percent of coral cover that was bleached and average bleaching severity (rounded to the nearest whole number) per island for all depths combined. Sample size ranged from 7 to 64 sites per island (see Table 1 for full survey effort).**

Percent bleaching decreased along the depth gradient from shallow to deep sites at most islands (**Error! Reference source not found.**). For both the MHI and the NWHI, the most severe bleaching occurred at shallow sites.



**Figure 4. Mean ( $\pm 1$  SE) percent of coral cover that was bleached and average bleaching severity (rounded to the nearest whole number) per depth stratum and island. No surveys were conducted within the deep stratum at French Frigate Shoals and Hawai'i. Sample size ranged from 2 to 29 sites per stratum (see Table 1 for full survey effort).**

Bleaching susceptibility, the percent of coral that was bleached, varied by taxa (**Error! Reference source not found.**). Certain taxa demonstrated greater resistance to bleaching, and this held across space (e.g., *Montipora patula*). Of the species observed, *Porites duerdeni* (only observed at Maui sites) was the most susceptible taxa to bleaching, followed by *Pavona duerdeni* (absent only at Lāna'i sites). Of the most abundant taxa, *Montipora capitata* and *Pocillopora meandrina* were the most affected by bleaching. The high variability in bleaching among taxa necessitates further analysis.



**Figure 5. Bleaching patterns across dominant coral species and islands in the MHI. Data not shown for taxa observed at fewer than three sites per island (represented by gaps between bars). Number of species occurrences per island shown within or next to bars.**

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